CHAPTER 2.0 ANSWER

1. A tank is filled with seawater to a depth of 12 ft. If the specific gravity of seawater is 1.03 and the atmospheric pressure at this location is 14.8 psi, the absolute pressure (psi) at the bottom of the tank is most nearly

A.5.4

B.20.2

C.26.8

D.27.2

Hint: Absolute pressure = gage pressure + atmospheric pressure

where, gage pressure = $\gamma_z h$ and γ_z = specific weight of seawater = SG x γ_w

Solution:

γ_z = 1.03 (62.4 lb/cu ft) = 64.27 lb/cu ft

Gage pressure at the bottom of the tank = (12 ft) x (64.37 lb/cu ft) = 772.44 lb/sq ft

= (772.44 lb/sq ft)/(144 sq in/sq ft)= 5.36 psi

Absolute pressure = 14.8 psi + 5.36 psi= 20.16 psi

Therefore, the key is (B).

2.An open tank contains brine to a depth of 2 m and a 3-m layer of oil on top of the brine. Density of brine is 1,030 kg/m^3 and the density of oil is 880 kg/m^3. The gage pressure (kPa) at the bottom of the tank is most nearly

A.4.7

B.20.2

C.25.6

D.46.1

Hint: Pressure due to each layer of liquid = h γ where h is the height of the liquid layer and γ is the specific weight of the liquid.

Solution:

Since it is required to determine the gage pressure, pressure at the free surface = 0

Pressure due to the oil layer = (3 m) {(880 kg/m^3)(9.81 m/s^2)}/1,000= 25.9 kPa

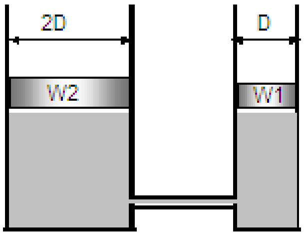
Pressure due to the brine layer= (2 m) {(1,030 kg/m^3)(9.81 m/s^2)}/1,000= 20.2 kPa

Hence pressure at the bottom= 25.9 + 20.2 = 46.1 kP

Note: 1 kg-ms^2 = 1 N; 1 N/m^2 = 1 Pa

Therefore, the key is (D).

3.The figure shows two cylinders of diameter D and 2D, connected to each other and containing an incompressible fluid. The two cylinders are fitted with leak-proof pistons of weight W_1 and W_2 as shown. Which of the following is a correct expression?



A.$W_2 = W_1/2$

B.$W_2 = W_1$

C.$W_2 = 2\ W_1$

D.$W_2 = 4\ W_1$

Hint: The pressure is the same in both cylinders. Pressure = Weight/area

Solution:

Considering the weight W_1, pressure $= \frac{W_1}{\pi D^2/4} = \frac{4W_1}{\pi D^2}$

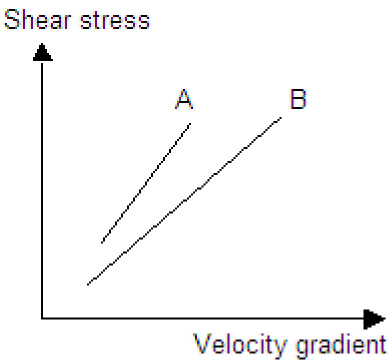
Considering the weight W_2, pressure $= \frac{W_2}{\pi (2D)^2/4} = \frac{W_2}{\pi D^2}$

Equating the two, $\frac{4W_1}{\pi D^2} = \frac{W_2}{\pi D^2}$

Hence, $W_2 = 4\ W_1$

Therefore, the key is (D).

4.The figure shows the relationship between shear stress and velocity gradient for two fluids, A and B. Which of the following is a true statement?



A.Absolute viscosity of A is greater than that of B

B.Absolute viscosity of A is less than that of B

C.Kinematic viscosity of A is greater than that of B

D.Kinematic viscosity of A is less than that of B

Hint: By definition, absolute viscosity $= \dfrac{\text{shear stress}}{\text{velocity gradient}}$

Thus, slope of the lines in the plot is absolute viscosity.

Kinematic viscosity = absolute viscosity/density.

Solution:

Since the slope of the line for A is greater than that for B, viscosity of A is greater than that of B.

Therefore, the key is (A).

5.A flat plate is sliding at a constant velocity of 5 m/s on a large horizontal table. A thin layer of oil (of absolute viscosity = 0.40 N-s/m^2) separates the plat from the table. To limit the shear stress in the oil layer to 1 kPa, the thickness of the oil film (mm) should be most nearly

A.0.2

B.1.6

C.2.0

D.3.5

Hint: By definition, absolute viscosity, μ $= \dfrac{\text{shear stress}}{\text{velocity gradient}}$

where, velocity gradient = DU/d, DU = difference in velocity across the oil film; and d = the thickness of the oil film.

Solution:

DU = (5 – 0) m/s = 5 m/s

Hence, $$\delta = \frac{\mu}{\tau}\Delta U = \frac{\left(0.40\ N-s/m^2\right)}{\left(1\ kPa\right)\left(1{,}000\ Pa/kPa\right)}\left(5\ m/s\right) = 0.002\ m = 2\ mm$$

Therefore, the key is (C).

6.A 2-in. diameter shaft is supported by two sleeves, each of length = 2 in. as shown. The internal diameter of the sleeves is 2.1 in. The radial space between the shaft and the sleeves is filled with an oil of viscosity = $8\text{x}10^{-3}$ lb-s/ft^2. If the shaft is rotated at a speed of 600 rpm, the viscous torque (ft-lb) on the shaft is most nearly

A. 0.15

B. 0.64

C. 3.20

D. 6.40

Hint: Torque, T = (Shear force, F) x (Radius, R)

Shear force = (Shear stress, t) x (Area, A)

Shear stress, t = μ dU/dy

Solution:

DU/Dy = R1w/(R2 – R1) = {(1/12 ft) (600 x 2p/60)}/(1.05/12 – 1.0/12)= 1256.64 s-1

Shear stress, t = (8x10-3 lb-s/ft2)(1256.64 s-1)= 10.05 lb/sq ft

Shear force per sleeve = t x A = t x [(2pR1)(L)]

= (10.05 lb/sq ft) [(2p(1/12)(2/12)]= 0.88 lb

Torque per sleeve= (0.88 lb) (1/12 ft)= 0.07 ft-lb

Torque for 2 sleeves= 0.15 ft-lb

Therefore, the key is (A).

7.A 2-in. diameter cylinder is floating vertically in seawater with 75% of its volume submerged. If the specific gravity of seawater is 1.03, the specific weight (lb/cu ft) of the cylinder is most nearly

A. 48.2

B. 64.2

C. 83.2

D. 85.7

Hint: When a body is floating in a fluid, weight of the body, W (= V γ_b) is balanced by the buoyancy force, F_b (= V_d γ_f) where,

V = volume of the body

γ_b = specific weight of the body

V_d= volume displaced

γ_f = specific weight of the fluid

Solution:

Equating W to F_b,

V γ_b = V_d γ_f

γ_b = (V_d) γ_f

where, γ_f = 1.03 gw = 1.03 (62.4 lb/cu ft) = 64.27 lb/cu ft

Hence, γ_b = 0.75 (64.27 lb/cu ft) = 48.20 lb/cu ft

Therefore, the key is (A).

8.A clean glass tube is to be selected in the design of a manometer to measure the pressure of kerosene. Specific gravity of kerosene = 0.82 and surface tension of kerosene = 0.025 N/m. If the capillary rise is to be limited to 1 mm, the smallest diameter (cm) of the glass tube should be most nearly

A. 1.25

B. 1.50

C. 1.75

D. 2.00

Hint: The capillary rise, $h = \frac{4\sigma \cos\beta}{\gamma d}$

where, s = surface tension of the fluid; b = angle of contact; g = specific weight of the fluid; d = diameter of tube.

Solution:

Rearranging the equation for the capillary rise and substituting the given data,

$$d = \frac{4\sigma \cos\beta}{\gamma h}$$

$$= \frac{4(0.025\ N/m)(\cos 0)}{(0.82\times 9.8\ kN/m^3 \times 1{,}000\ N/kN)(1/1{,}000\ m)} = 0.0124\ m = 1.24\ cm$$

Therefore, the key is (A).

9.An object weighs 275 N when fully immersed in water and 325 N when fully immersed in oil of specific gravity 0.9. The volume of the object (m^3) is most nearly

A. 0.02

B. 0.05

C. 0.20

D. 0.50

Hint: When an object is fully immersed in a fluid, the apparent weight = W - F_b, where,

W = true weight of the object

F_b = buoyancy force = $V\gamma_f$

V= volume of object

γ_f = specific weight of the fluid

Solution:

When the object is fully immersed in water, 275 N = W – Vgw

or, W = 275 N + Vgw(1)

When the object is fully immersed in oil, 325 N = W – V

or, W = 325 N + Vgoil (2)

Subtracting (1) from (2),

0 = 50 N – V(gw – goil)

or, $V = \frac{50\ N}{(\gamma_w - \gamma_{oil})} = \frac{50\ N}{\gamma_w(1 - SG_{oil})} = \frac{50\ N}{(9{,}800\ N/m^3)(1-0.9)} = 0.051\ m^3$

Therefore, the key is (B).

10. A block of volume V and specific gravity, SG, is anchored by a light cable to the bottom of a lake as shown. If the specific weight of the water in the lake is gw, the tension, T, in the cable is given by

A. $T = \dfrac{V(1 - SG)}{\gamma_w}$

B. $T = \dfrac{V}{\gamma_w(1 - SG))}$

C. $T = V\gamma_w(1 - SG)$

D. $T = \dfrac{V\gamma_w}{(1 - SG)}$

Hint: The force balance on the block is: $F_b = T + W$

$F_b = V\gamma w$

W = weight of the block= $V\gamma b$= $V(SG\ \gamma w)$

Solution:

From the force balance,

$T = F_b - W = V\gamma_w - V(SG\ \gamma_w)$

Hence, $T = V\gamma_w (1 - SG)$

Therefore, the key is (C).

11. When a uniform flat plate is placed horizontally at a depth of h as shown in Figure 1, the magnitude of the force exerted by the fluid on the plate is 20 kN. When this plate is tilted about its center of gravity through 30º as shown in Figure 2, the magnitude of the force (kN) exerted by the fluid on the plate is most nearly

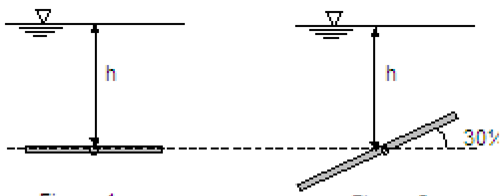


Figure 1 Figure 2

A. 20 sin 30

B. 20 cos 30

C. 20 tan 30

D. 20

Hint: The force balance on a flat plate = $\gamma f\ A\ d_c$

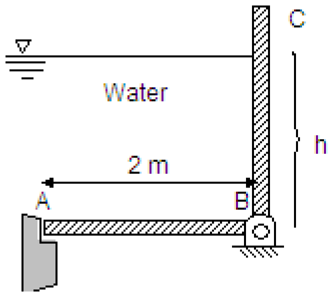
Where, γ_f is the specific weight of the fluid; A is the area of the plate; and d_c is the depth of center of gravity of the plate.

Solution:

Since the depth of center of gravity is the same in both cases, and the area is the same, the magnitude of the force will also be the same.

Therefore, the key is (D).

12. The figure shows an L-shaped gate ABC hinged at B. Ignoring the weight of the gate, the value of h (m) when the gate is about to open is most nearly



A. 2.0

B. 2.5

C. 3.0

D. 3.5

Hint: Let the hydraulic force on side AB = F_1 and the hydraulic force on side BC = F_2. When the gate is about to open,

the moment of F_1 about B should equal the moment of F_2 about B. Hydraulic force on any surface = γAdc where, γ = specific weight of water,

A = area of the surface; d_c = depth of center of gravity of the surface.

Solution:

Considering unit width of the gate, F_1 = (9.81 kN/m3)(2 m x 1 m) (h m) = 19.62h kN and,

F_2 = (9.81 kN/m3)(h m x 1 m) (h/2 m) = 4.9h2 kN

Moment of F_1 about B = F1 x 1 m = (19.62h kN) (1 m) = 19.62h kN-m

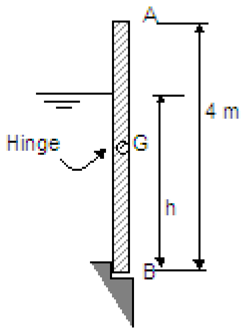
Moment of F_2 about B = F2 x h/3 = (4.9h2 kN) (h/3 m) = 1.63h3 kN-m

Equating the above two, 19.62h kN-m = 1.63h3 kN-m

Hence, h = $\sqrt{}$ (19.62/1.63) = 3.47 m

Therefore, the key is (D).

13. The figure shows a gate made of a uniform plate of height 4 m and width 1 m, hinged about it a horizontal axis through its center of gravity, G. Depth of water on the upstream side of the plate, h is 3 m. The magnitude of the minimum force (kN) that must be applied at A to keep the gate in the vertical position is most nearly



A. 22

B. 26

C. 41

D. 66

Hint: The force at A will be minimum when it is applied horizontally. The moment of this force about the hinge should balance the moment due

to the hydraulic force on the plate. Hydraulic force on the plate = $A\gamma d_c$ where, A = area of the submerged portion; γ = specific weight of water; and d_c

is the depth of center of gravity of the submerged portion.

Solution:

Hydraulic force on gate, F = (3 m x 1 m)(9.8 kN/m3)(3 m/2) = 44.1 kN

Moment of the hydraulic force about the hinge, F x (2 m – h/3) = 44.1 kN-m

Hence the minimum force at A to hold the plate in the vertical position = 44.1 kN-m/2 m = 22.05 kN.

Therefore, the key is (A).

14. The figure shows the cross section of a dam. Assume the specific weight of water as 62.4 lb/cu ft. Considering unit width of the dam, the maximum moment of the hydraulic force on the dam about point P (ft-lb) is most

nearly

A. 0.8×10^6

B. 1.3×10^6

C. 2.6×10^6

D. 3.9×10^6

Hint: The moment will be maximum when the water depth rises to the top of the dam.

Moment about P = Force, F x distance of point of action from P, y

Force, F = γ_f A d_c

where, γ_f = specific weight of fluid = 62.4 lb/cu ft

A = submerged area

d_c = depth of center of gravity of submerged area

Distance from P, y = 1/3 of submerged depth

Solution:

Considering unit width of the dam, A = 50 ft x 1 ft = 50 ft2

d_c of submerged depth = 1/2 (50 ft)= 25 ft

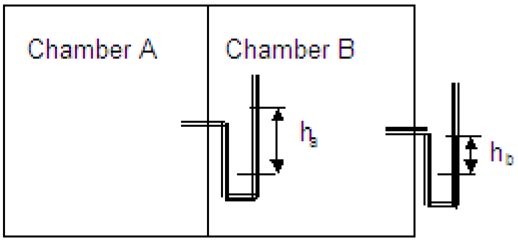
Maximum hydraulic force on the dam, F= (62.4 lb/cu ft)(50 ft2)(25 ft)= 78,000 lb

Distance of point of action from P= 1/3 (50 ft)= 16.67 ft

Maximum moment= (78,000 lb) (16.67 ft)= 1.3 x 106 ft-lb

Therefore, the key is (B).

15. The figure shows two chambers A and B, where two manometers are being used to measure the pressure. The manometeric fluid is the same in both manometers, with a specific gravity of 1.4. When h_a = 6 cm and h_b = 4 cm, the gage pressure in chamber A (kPa) is most nearly



A. 0.98

B. 1.37

C. 98

D. 137

Hint: Let p_A = gage pressure in chamber A and p_B = gage pressure in chamber B. Relate p_A to p_B using manometric

deflection, h_a, and relate p_B to patm using manometric deflection, h_b.

Solution:

$p_B = p_A - h_a \gamma_m = p_A - h_a (SG\ \gamma_w)$

patm = $p_B - h_b \gamma_m = p_B - h_b (SG\ \gamma_w)$

Combing the above two equations, $p_A - p_{atm} = p_{A,gage} = (h_a + h_b)\gamma_m = (h_a + h_b)(SG\ \gamma_w) =$ [(6/100 m + 4/100 m)](1.4)k = 1.37 kPa

Therefore, the key is (B).

16.A manometer is being used as shown to measure the pressure in a pressurized tank. The tank is partially filled to a depth of 25 cm with a fluid of specific gravity (SG) = 0.78. The specific gravity (SG) of the manometric gage fluid is 3.5. The gage pressure in the headspace (kPa) when h = 8 cm is most nearly

A. 0.02

B. 0.22

C. 2.21

D. 22.15

Hint: Let the gage pressure in headspace to be p.

The pressure at depth h = p at the surface + γ_h

where γ is the specific weight of the fluid.

Find a horizontal plane and equate the pressure exerted by the two fluids at that plane.

Solution:

With the interface of the two fluids as a reference plane, considering the fluid in tank,

Pressure at the interface = p + (0.78 x 9.8 kN/m3) (25 cm + h cm)/100

Considering the gage fluid,

Pressure at the interface = patm. + (3.5 x 9.8 kN/m3) (h cm)/100

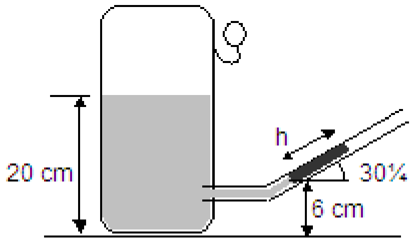
Equating the two, with $p_{atm.} = 0$

p = (3.5 x 9.8 kN/m3) (h cm)/100 - (0.78 x 9.8 kN/m3) (25 cm + h cm)/100

substituting h = 8/100 m, p = 0.22 kPa.

Therefore, the key is (B).

17. An inclined-tube manometer is being used as shown to measure the pressure in a pressurized tank. The tank is partially filled to a depth of 20 cm with a fluid of specific gravity = 0.78. The specific gravity of the manometric gage fluid is 3.5. The gage pressure in the headspace (kPa) when h = 8 cm is most nearly



A. 0.3

B. 0.9

C. 1.2

D. 1.8

Hint: Let the gage pressure in headspace to be p. Find the pressure at the interface in terms of the height and specific weight

of the gage fluid and equate that to the pressure in the tank at that horizontal level to find p.

Solution:

Gage pressure at the interface due to gage fluid = ggage (h sin 30º) = (3.5 x 9.8 kN/m3)(0.08 m sin 30º) = 1.372 kPa

p + [(20 – 6)/100 m](0.78 x 9.8 kN/m3) = 1.372 kPa Therefore, p = 1.372 kPa – [(20 – 6)/100 m](0.78 x 9.8 kN/m3) = 0.30 kPa

Therefore, the key is (A).

18. For a body partially submerged in a fluid and at equilibrium, which of the following is a true statement?

A. The weight of the body is equal to the weight of the volume of fluid displaced

B. The weight of the body is less than the weight of the volume of fluid displaced

C. The weight of the body is greater than the weight of the volume of fluid displaced

D. The specific gravity of the body is greater than the specific gravity of the fluid

Hint: When a body is partially or fully submerged in a fluid, the fluid exerts a vertical force on the body known as the buoyancy force.

This buoyancy force is equal to the weight of the fluid volume displaced by the body.

Solution:

Since the body is at equilibrium, the weight of the body should equal the buoyancy force, which in turn is equal to the weight of the volume of fluid displaced.

Thus, the weight of the body is equal to the weight of the volume of fluid displaced.

Therefore, the key is (A).